the plant leaf tissue occurred as a result of the dosage when the process was performed at sub-zero temperatures and the pulse duty cycle minimized sample heating.

Features, specifications, and functionality of the hardware, operating software, sonic energy profile, and positioning profile of certain embodiments of a system according to the invention are described in FIGS. 10-13. As noted, some of these embodiments can be used effectively for treating a sample for the purpose of extraction or transformation or general research; however, these embodiments are to be considered exemplary in nature, and not limiting of the invention.

While there has been described herein what are considered to be exemplary and preferred embodiments of the invention, other modifications and alternatives of the inventions will be apparent to those skilled in the art from the teachings herein. All such modifications and alternatives are considered to be within the scope of the invention.

Accordingly, what is desired to be secured by Letters Patent is the invention as defined and differentiated in the following claims and equivalents thereof.

What is claimed is:

Claims

1. An apparatus for processing a sample using sonic energy, the apparatus comprising:

a sonic energy source for emitting sonic energy;

a holder for the sample, the sample movable relative to the emitted sonic energy; and

a processor for controlling the sonic energy source and location of the sample according to a predetermined methodology, such that the sample is selectively exposed to sonic energy to produce a desired result.

2. The apparatus of claim 1 further comprising a feedback system connected to the processor for monitoring at least one condition to which the sample is subjected during processing, such that the processor controls at least one of the sonic energy source and the location of the sample in response to the at least one condition.

3. The apparatus of claim 1 wherein the desired result is selected from the group consisting of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the sample, disrupting the sample, increasing permeability of a component of the sample, enhancing a reaction within the sample, and sterilizing the sample.

4. The apparatus of claim 1 further comprising a temperature control unit for controlling temperature of the sample.

5. The apparatus of claim 4 wherein the processor controls the temperature control unit.

6. The apparatus of claim 1 further comprising a pressure control unit for controlling pressure to which the sample is exposed.

7. The apparatus of claim 6 wherein the processor controls the pressure control unit.

8. The apparatus of claim 1 wherein the sonic energy source comprises a transducer.

9. The apparatus of claim 8 wherein the transducer focuses the sonic energy.

10. The apparatus of claim 8 wherein the transducer is selected from the group consisting of at least one piezoelectric element, an array of piezoelectric elements, an electrohydraulic element, a magnetostrictive element, an electromagnetic transducer, a chemical explosive element, a laser-activated element, and combinations thereof.

11. The apparatus of claim 10 wherein the at least one piezoelectric element includes a spherical transmitting surface oriented such that the focal axis is vertical.

12. The apparatus of claim 1 wherein the holder supports a sample container for containing the sample.

13. The apparatus of claim 12 wherein the sample container is selected from the group consisting of a membrane pouch, a thermopolymer well, a polymeric pouch, a hydrophobic

membrane, a microtiter plate, a microtiter well, a test tube, a centrifuge tube, a microfuge tube, an ampoule, a capsule, a bottle, a beaker, a flask, and a capillary tube.

14. The apparatus of claim 12 wherein the sample container forms multiple compartments.

15. The apparatus of claim 12 wherein the sample container includes a rupturable membrane for transferring a fraction of the sample away from the holder.

16. The apparatus of claim 1 further comprising a device for moving the sample from a first location to a second location.

17. The apparatus of claim 16 wherein the device for moving the sample comprises a stepper motor.

18. The apparatus of claim 2 wherein the feedback system comprises a sensor for monitoring the at least one condition.

19. The apparatus of claim 1 further comprising an acoustically transparent material disposed between the sonic energy source and the holder.

20. The apparatus of claim 1 wherein the desired result comprises an in vitro treatment.

21. The apparatus of claim 1 wherein the desired result comprises an ex vivo treatment.

22. The apparatus of claim 1 wherein the sample flows through a conduit.

23. The apparatus of claim 1 wherein the sonic energy source generates sonic energy at two different frequencies.

24. The apparatus of claim 1 wherein sonic energy source generates a wavetrain.

25. The apparatus of claim 24 wherein the wavetrain comprises a first wave and a different second wave.

26. The apparatus of claim 24 wherein the wavetrain comprises about 1000 cycles per burst at about a 10% duty cycle at about 500 mV.

27. A method for processing a sample with sonic energy, the method comprising the steps of:

exposing the sample to sonic energy; and

controlling at least one of the sonic energy and location of the sample relative to the sonic energy according to a predetermined methodology, such that the sample is selectively exposed to sonic energy to produce a desired result.

28. The method of claim 27 further comprising the steps of sensing at least one condition to which the sample is subjected during processing and altering at least one of the sonic energy and the location of the sample in response to the at least one condition.

29. The method of claim 28 wherein during the sensing step, the at least one condition is selected from the group consisting of temperature, pressure, an optical property, an altered chemical, an acoustic signal, and a mechanical occurrence.

30. The method of claim 28 wherein during the altering step, at least one characteristic of the sonic energy is altered, the at least one characteristic selected from the group consisting of wave form, duration of application, intensity, and duty cycle.

31. The method of claim 27 wherein the desired result is selected from the group consisting of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the sample, disrupting the sample, increasing permeability of a component of the sample, enhancing a reaction within the sample sterilizing the sample, and combinations thereof.

32. The method of claim 27 further comprising the step of controlling temperature of the sample.

33. The method of claim 27 further comprising the step of controlling pressure to which the sample is exposed.

34. The method of claim 27 wherein during the step of exposing the sample to sonic energy, the sonic energy is generated by at least one process selected from the group consisting of spark discharges across a gap, laser pulses, piezoelectric pulses, electromagnetic shock waves, electrohydraulic shock waves, electrical discharges into a liquid, and chemical explosives.

35. The method of claim 27 wherein the sonic energy is focused on the sample.

36. The method of claim 27 wherein the sample contains a cell, the method further comprising the step of introducing a material into the cell.

37. The method of claim 36 wherein the material is selected from the group consisting of a polymer, an amino acid monomer, an amino acid chain, a protein, an enzyme, a nucleic acid monomer, a nucleic acid chain, a saccharide, a polysaccharide, an organic molecule, an inorganic molecule, a vector, a plasmid, a virus, and combinations thereof.

38. The method of claim 27 further comprising the step of extracting a component of the sample.

39. The method of claim 27 wherein during the controlling step, at least one characteristic of the sonic energy is controlled, the at least one characteristic selected from the group consisting of wave form, duration of application, intensity, and duty cycle.

40. The method of claim 27 wherein the desired result comprises an in vitro treatment.

41. The method of claim 27 wherein the desired result comprises an ex vivo treatment.

42. The method of claim 27 further comprising the step of the sample flowing through a conduit.

43. The method of claim 27 wherein the sonic energy comprises at least two different frequencies.

44. The method of claim 27 wherein sonic energy source comprises a wavetrain.

45. The method of claim 44 wherein the wavetrain comprises a first wave and a different second wave.

46. The method of claim 44 wherein the wavetrain comprises about 1000 cycles per burst at about a 10% duty cycle at about 500 mV.

Claims

1. An apparatus for processing a sample using sonic energy, the apparatus comprising:

a sonic energy source for emitting sonic energy wherein the energy source generates a wavetrain;

a holder for the sample, the sample movable relative to the emitted sonic energy; and

a processor for controlling the sonic energy source and location of the sample according to a predetermined methodology, such that the sample is selectively exposed to sonic energy to produce a desired result.

2. The apparatus of claim 1 further comprising a feedback system connected to the processor for monitoring at least one condition to which the sample is subjected during processing, such that the processor controls at least one of the sonic energy source and the location of the sample in response to the at least one condition.

3. The apparatus of claim 1 wherein the desired result is selected from the group consisting of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the sample, disrupting the sample, increasing permeability of a component of the sample, enhancing a reaction within the sample, and sterilizing the sample.

4. The apparatus of claim 1 further comprising a temperature control unit for controlling temperature of the sample.

5. The apparatus of claim 4 wherein the processor controls the temperature control unit.

6. The apparatus of claim 1 further comprising a pressure control unit for controlling pressure to which the sample is exposed.

7. The apparatus of claim 6 wherein the processor controls the pressure control unit.

8. The apparatus of claim 1 wherein the sonic energy source comprises a transducer.

9. The apparatus of claim 8 wherein the transducer focuses the sonic energy.

10. The apparatus of claim 8 wherein the transducer is selected from the group consisting of at least one piezoelectric element, an array of piezoelectric elements, an electrohydraulic element, a magnetostrictive element, an electromagnetic transducer, a chemical explosive element, a laser-activated element, and combinations thereof.

11. The apparatus of claim 10 wherein the at least one piezoelectric element includes a transmitting surface oriented such that the focal axis is vertical.

12. The apparatus of claim 1 wherein the holder supports a sample container for containing the sample.

13. The apparatus of claim 12 wherein the sample container is selected from the group consisting of a membrane pouch, a thermopolymer well, a polymeric pouch, a hydrophobic membrane, a microtiter plate, a microtiter well, a test tube, a centrifuge tube, a microfuge tube, an ampoule, a capsule, a bottle, a beaker, a flask, and a capillary tube.

14. The apparatus of claim 12 wherein the sample container forms multiple compartments.

15. The apparatus of claim 12 wherein the sample container includes a rupturable membrane for transferring a fraction of the sample away from the holder.

16. The apparatus of claim 1 further comprising a device for moving the sample from a first location to a second location.

17. The apparatus of claim 16 wherein the device for moving the sample comprises a stepper motor.

18. The apparatus of claim 2 wherein the feedback system comprises a sensor for monitoring the at least one condition.

19. The apparatus of claim 1 further comprising an acoustically transparent material disposed between the sonic energy source and the holder.

20. The apparatus of claim 1 wherein the desired result comprises an in vitro treatment.

21. The apparatus of claim 1 wherein the desired result comprises an ex vivo treatment.

22. The apparatus of claim 1 wherein the sample flows through a conduit.

23. The apparatus of claim 1 wherein the sonic energy source generates sonic energy at at least two different frequencies.

24. Cancelled.

25. The apparatus of claim 1 wherein the wavetrain comprises a first wave and a different second wave.

26. The apparatus of claim 1 wherein the wavetrain comprises about 1000 cycles per burst at about a 10% duty cycle at about 15 MPa.

27. A method for processing a sample with sonic energy, the method comprising the steps of:

exposing the sample to sonic energy wherein the sonic energy comprises a wavetrain; and

controlling at least one of the sonic energy and location of the sample relative to the sonic energy according to a predetermined methodology, such that the sample is selectively exposed to sonic energy to produce a desired result.

28. The method of claim 27 further comprising the steps of sensing at least one condition to which the sample is subjected during processing and altering at least one of the sonic energy and the location of the sample in response to the at least one condition.

29. The method of claim 28 wherein during the sensing step, the at least one condition is selected from the group consisting of temperature, pressure, an optical property, an altered chemical, an acoustic signal, and a mechanical occurrence.

30. The method of claim 28 wherein during the altering step, at least one characteristic of the sonic energy is altered, the at least one characteristic selected from the group consisting of wave form, duration of application, intensity, and duty cycle.

31. The method of claim 27 wherein the desired result is selected from the group consisting of heating the sample, cooling the sample, fluidizing the sample, mixing the sample, stirring the sample, disrupting the sample, increasing permeability of a component of the sample, enhancing a reaction within the sample sterilizing the sample, and combinations thereof.

32. The method of claim 27 further comprising the step of controlling temperature of the sample.

33. The method of claim 27 further comprising the step of controlling pressure to which the sample is exposed.

34. The method of claim 27 wherein during the step of exposing the sample to sonic energy, the sonic energy is generated by at least one process selected from the group consisting of spark discharges across a gap, laser pulses, piezoelectric pulses, electromagnetic shock waves, electrohydraulic shock waves, electrical discharges into a liquid, and chemical explosives.

35. The method of claim 27 wherein the sonic energy is focused on the sample.

36. The method of claim 27 wherein the sample contains a cell, the method further comprising the step of introducing a material into the cell.

37. The method of claim 36 wherein the material is selected from the group consisting of a polymer, an amino acid monomer, an amino acid chain, a protein, an enzyme, a nucleic acid monomer, a nucleic acid chain, a saccharide, a polysaccharide, an organic molecule, an inorganic molecule, a vector, a plasmid, a virus, and combinations thereof.

38. The method of claim 27 further comprising the step of extracting a component of the sample.

39. The method of claim 27 wherein during the controlling step, at least one characteristic of the sonic energy is controlled, the at least one characteristic selected from the group consisting of wave form, duration of application, intensity, and duty cycle.

40. The method of claim 27 wherein the desired result comprises an in vitro treatment.

41. The method of claim 27 wherein the desired result comprises an ex vivo treatment.

42. The method o[illegible]aim 27 further comprising the step of [illegible] sample flowing through a conduit.

43. The method of claim 27 wherein the sonic energy comprises at least two different frequencies.

44. Cancelled.

45. The method of claim 27 wherein the wavetrain comprises a first wave and a different second wave.

46. The method of claim 27 wherein the wavetrain comprises about 1000 cycles per burst at about a 10% duty cycle at about 15 MPa.